ELECTRIC TOOTHBRUSHES HAVING FLEXIBLE NECKS

JOHN GEOFFREY CHAN

This application claims the benefit of U.S. Provisional Application No. 60/410,864, filed September 13, 2002, and U.S. Provisional Application No. 60/410,902, filed September 13, 2002, the substance of which is incorporated herein by reference.

Field of the Invention

The present invention relates to the field of electric toothbrushes, and particularly, to electric toothbrushes having flexible necks.

Background of the Invention

Flexible neck toothbrushes are known in the art. Flexible necks can increase brushing efficacy since the brush head may be better oriented to specific relationships with a user's teeth and gums. Secondly, if appropriately configured, a flexible neck may limit the amount of force applied to the teeth and gums during brushing. It is documented that excessive brushing force can be deleterious to the user's teeth and gums.

Traditionally, electric toothbrushes utilize a relatively rigid hollow neck. This is primarily due to the fact that a moving drive mechanism resides within the handle and neck portion of the toothbrush. In an alternate arrangement, U.S. Patent No. 4,845,796 discloses an electric toothbrush having a rotating flexible stem that frictionally engages a motor. The rotating flexible stem is not disposed within a neck structure that is separately attached to the handle of the electric toothbrush. While the prior designs may have been suitable for their intended purpose, there is a continuing need to provide electric toothbrushes having flexible necks that can accommodate bristle carriers that move in other and more complex motions. Further, there is a desire to provide electric toothbrushes having flexible neck that can include static as well as moving bristles. Still further, there is a desire to provide electric toothbrushes

having flexible necks in which the direction and amount of flexure can be controlled. Yet further, there is a continuing desire to provide electric toothbrushes having flexible necks that have simplified constructions.

Summary of the Invention

An electric toothbrush is provided. The electric toothbrush includes a handle having an interior cavity, a head, and a flexible neck extending between the handle and the head. The head has a movable bristle carrier that is driven by a motor disposed within the cavity of the handle. A shaft is disposed within the flexible neck that is operatively connected to the movable bristle carrier and to the motor.

Brief Description of the Drawings

The present invention may take form in various components and arrangements of components, and in various techniques, methods, or procedures and arrangements of steps. The referenced drawings are only for purposes of illustrating preferred embodiments, they are not necessarily to scale, and are not to be construed as limiting the present invention.

It is believed that the present invention will be better understood from the following description taken in conjunction with the accompanying drawings in which:

Fig. **1** is a perspective view of a toothbrush made in accordance with the present invention.

Fig. **2** is a front elevational view of the toothbrush of Fig. **1**.

Fig. **3** is a side elevational view of the toothbrush of Fig. **1**.

Fig. **4** is a cross-sectional view of a neck of the toothbrush of Fig. **1**, taken along line **4-4** in Fig. **1**.

Fig. **5** is a partial fragmentary perspective view of the toothbrush of Fig. **1**.

Fig. **6** is a side elevational view of the toothbrush of Fig. **5**.

Fig. **7** is a cross-sectional view taken along line 7-7 of Fig. **6**.

Fig. **8** is a partial exploded view of a movable bristle carrier and drive shaft of the toothbrush of Fig. **5**.

Fig. **9** is a perspective view of a motor and drive train suitable of the toothbrush of Fig. **5**.

Fig. **10** is a front elevational view of the toothbrush of Fig. **1**.

Fig. **11** is a side elevational view of the toothbrush of Fig. **1**.

Figs. **12** to **20** are cross-sectional views of various toothbrush neck configurations.

Fig. **21** to **23** are side elevational views of some toothbrush heads suitable for use with a flexible neck.

Fig. **24** is a side elevational view of movable bristle carrier suitable for use with a flexible neck.

Fig. **25** is an end view of the movable bristle carrier of Fig. **24**.

Fig. **26** is a side elevational view of movable bristle carrier suitable for use with a flexible neck.

Fig. **27** is an end view of the movable bristle carrier of Fig. **26**.

Fig. **28** is a side elevational view of movable bristle carrier suitable for use with a flexible neck.

Fig. **29** is an end view of the movable bristle carrier of Fig. **28**.

Detailed Description of the Preferred Embodiments

All patents, patent publications, ASTM and ISO standards referenced herein, including U.S. Provisional Application No. 60/410,864, filed September 13th, 2002, and U.S. Provisional Application No. 60/410,902, filed September 13th, 2002 are incorporated herein by reference. The electric toothbrushes of the present invention incorporate a neck that is flexible and resilient, meaning that at least a portion of the neck can assume a curved or curvilinear shape or otherwise bend when a tooth brushing force is applied to the toothbrush head. This deflection can occur over the entire neck or only a portion thereof, such as shown in Figs. 2 and 3. It will be appreciated that the neck can assume a curved shape having a single radius of curvature or multiple radii of

curvature. Further, it will be appreciated that the present invention can be adapted to an electric toothbrush head to provide a flexible head. The flexible neck can be achieved by forming the neck from a mixture of polymers or varying the cross-sectional shape of the neck in combination with the appropriate polymer or blend of polymers.

By utilizing a mixture of polymers in the neck, various degrees of flexibility in the region of the neck may be achieved. Preferably, the polymer mixture is a blend of a first polymer with a second polymer that has a lower flexural modulus, i.e., that is generally more flexible, than the first polymer. Additionally and preferably, the hardness of the second polymer is less than that of the first polymer. Specifically, the Shore A hardness of the second polymer is preferably from about 25 to about 85. Standards for determining Shore A hardness are set forth in ASTM D 2240 and the standards for determining flexural modulus are set forth in ASTM D790 and ISO 178.

Preferably, the weight ratio of the first polymer to the second polymer is from about 95:5 to about 30:70. It is believed that this ratio is dependent on the hardness of the second polymer material. For example, for the following Shore A hardness ranges of the second polymer, the corresponding ratios of the first polymer to the second polymer are preferred. For a Shore A hardness of from about 25 to about 45, the preferred weight ratio of the first polymer to the second polymer is from about 90:10 to about 60:35, with from about 85:15 to about 65:35 being more preferred. For a Shore A hardness of from about 45 to about 65, the preferred weight ratio of the first polymer to the second polymer is from about 80:20 to about 50:50, with from about 75:25 to about 55:45 being more preferred. For a Shore A hardness of from about 65 to about 85, the preferred ratio of the first polymer to the second polymer is from about 70:30 to about 40:60, with from about 65:35 to about 45:55 being more preferred.

In the following description of the preferred polymer materials for use herein, the abbreviations that are commonly used by those of skill in the art to refer to certain polymers appear in parentheses following the full names of the polymers. The first polymer is preferably polypropylene ("PP"), or may be

selected from the group consisting of other conventional toothbrush handle materials, such as polystyrene ("PS"), polyethylene ("PE"), acrylonitrile-styrene copolymer ("SAN"), cellulose acetate propionate ("CAP"), and mixtures thereof. The second polymer is preferably a thermoplastic elastomer ("TPE"), a thermoplastic olefin ("TPO"), a soft thermoplastic polyolefin (e.g., polybutylene), or may be selected from other elastomeric materials, such as ethylene-vinylacetate copolymer ("EVA"), ethylene propylene rubber ("EPR"), and mixtures thereof. Examples of suitable thermoplastic elastomers herein include styrene-ethylene-butadiene-styrene ("SEBS"), styrene-butadiene-styrene ("SBS"), and styrene-isoprene-styrene ("SIS"). Examples of suitable thermoplastic olefins herein include polybutylene ("PB"), and polyethylene ("PE").

For toothbrushes, the handle and the head are commonly joined via a neck area, which as noted above may be of a smaller cross-sectional area than the handle or the head. The head is provided with apertures for receiving bristles or bundles of bristles, which are mechanically or thermally fixed therein, as is known to those of skill in the art. Any such method for fixing the bristles can be used herein.

Fig. **1** is a perspective view illustrating a preferred embodiment toothbrush **10** according to the present invention. The preferred embodiment toothbrush **10** comprises a handle **80**, a head **20**, and a neck **40** extending between the handle **80** and the head **20**. Disposed on the head **20** are a plurality of stationary bristles **60** and a plurality of movable bristles **50**. A number of bristle types, configurations, and arrangements may be used for the bristles. Examples of such aspects are disclosed and taught in the previously noted patents and furthermore in U.S. Design Patents 432,312; and 433,814. Most preferably, the movable bristles **50** are supported or otherwise secured to a movable bristle carrier (not shown) that is retained on the brush head **20**. As will be appreciated, the movable bristle carrier and the movable bristles **50** are powered by a motor and drive train or mechanism disposed in a hollow interior cavity defined within the body, i.e. the handle **80** of the toothbrush **10**. A switch or actuator **70** is provided along the outer region of the handle **80** and is operatively connected to

the motor and drive train and is used to control operation of the electric toothbrush **10**.

Figs. **2** and **3** illustrate front and side elevational views, respectively, of toothbrush **10** shown in Fig. **1**. It can be seen from these figures that the flexible neck **40** allows reversible or resilient lateral, rearward, and forward displacement of the head **20** with respect to the handle **80**. The term "reversible" as used herein refers to the ability of the toothbrush to be displaced in the noted direction and to the noted extent, without breakage or fracture of the toothbrush body or neck, and then to return to its previous state or orientation. Specifically, in accordance with the present invention, the degree of reversible lateral displacement of the head with respect to the longitudinal axis of the electric toothbrush is approximately from about 25 degrees to about 5 degrees and preferably from about 15 degrees to about 10 degrees. It is preferred that this flexibility or range of lateral displacement is equivalent for both lateral directions of movement of the brush head relative to the handle. Referring to Fig. **2**, this degree of movement is illustrated and shown as lateral flexure $\mathbf{F_L}$. That is, it can be seen from Fig. **2**, that the brush head **20** may be laterally displaced by an amount of flexure shown as $\mathbf{F_L}$ with respect to the longitudinal axis of the toothbrush when in a non-flexing or displaced state. The longitudinal axis of the toothbrush is shown in these figures as axis **A**.

Similarly, as noted, the toothbrush **10** may also undergo reversible rearward and forward flexure of the brush head with respect to the handle. This is shown in Fig. **3**. The preferred amount of reversible rearward flexure, shown in Fig. **3** as $\mathbf{F_R}$, ranges from about 15 degrees to about 5 degrees. The preferred amount of reversible forward flexure, shown in Fig. **3** as $\mathbf{F_F}$, ranges from about 15 degrees to about 5 degrees.

The previously noted flexures, i.e. $\mathbf{F_L}$, $\mathbf{F_R}$, and $\mathbf{F_F}$, result from application of a force to either the handle **80** or to the brush head **20**. The neck **40** is sufficiently flexible so that only a relatively slight force is necessary to achieve the noted flexures. The following ranges of force are given with regard to application of the force at the center of the brush head **20**, in the appropriate direction to result in the noted flexure. A lateral flexure $\mathbf{F_L}$ of from about 25

degrees to about 5 degrees, for the toothbrush **10**, results from application of a force between about 4 N or about 10 N to about 10 N or about 20 N, along a side of the brush head **20**. A rearward flexure F_R of from about 15 degrees to about 5 degrees results from application of a force between about 4 N or about 8 N to about 8 N or about 20 N along the front or bristle-containing face of the brush head **20**. A forward flexure F_F of from about 15 degrees to about 5 degrees results from application of a force between about 4 N or about 8 N to about 8 N or about 20 N along the rear or back face of the brush head **20**. A wide range of ratios of displacement to force are achievable by utilizing different types and blends of polymers in the neck or body of the toothbrush and different structures and dimensions of the neck and body.

The sample brushes were tested as follows. The test apparatus comprised a tensile tester (< 100 N), steel wire, and brush handle clamper.

The test samples were prepared by marking the samples with two marks. The first mark is made at 15 mm from the top of the brush head and the second mark is made at 80 mm from the top of the brush head. The samples were prepared at a temperature of 20° +/- 5°C, and this temperature is kept constant for four hours prior to start of the testing procedure.

The test procedure is as follows. A steel wire was folded having a diameter of about 2 mm and a length of about 250 mm and placed into the upper clamper of the tester. The brush handle was put into the brush handle gripper and fixed on the position of the second mark (with the brush bristles downward). The brush handle gripper was connected to the lower clamper of the tester and the steel wire placed on the position of the first mark. The tester was started up and the reading was taken when the sample was bent to 25 mm or broken. The result was measured in Newtons (N).

The testing conditions were ambient temperature maintained at 20° +/- 5°C. The rising up and dropping down speed of the tester was kept constant at 100 + 10 mm/min. In addition, the tensile tester was calibrated using a confirmed standard sample, or equipment manufacturer's calibration procedure.

The degree of flexibility of a sample is indicated in that a flexible sample is more easily deformed as compared to a relatively more rigid sample.

That is, the lower the amount of force needed to bend or break a brush, the more flexible the brush is. Therefore, lower values of N indicate greater flexibility.

Fig. **4** is a detailed cross-sectional view of the toothbrush **10** taken across line **4-4** in Fig. **1**. Fig. **4** reveals a hollow channel defined by an interior neck channel wall **42**. The interior configuration of this channel may be in a variety of forms. However, it is preferred that a generally rectangular or oval shape is preferred. The shape or configuration of the interior channel within the neck **40** is defined by an interior wall **42** as shown in Fig. **4**. It will be appreciated that one or more components of the drive mechanism extend and reside within this interior channel defined by wall **42**. Most preferably, a shaft or ribbon is disposed within the channel that undergoes reciprocating, rotating or oscillating motion upon activation of the motor. The size and configuration of the interior channel is preferably such that the wall **42** is in relatively close proximity to the outer surface of these components, however, a sufficient distance apart from these components during flexure of the neck so that contact does not occur between the wall **42** and component(s). In the event that contact occurs, it is contemplated that a friction reducing coating could be applied to the wall **42**, the exterior of the drive components, or both.

A preferred drive mechanism is illustrated in Figs. **5 to 9**, wherein a drive mechanism incorporating a flexible shaft or ribbon is illustrated. Fig. **5** is a partial fragmentary view of the preferred embodiment toothbrush **10** shown in Fig. **1**. Fig. **5** illustrates a motor **90** and a drive train or mechanism retained within the handle **80** that are used to move the collection of movable bristles **50** disposed on the brush head **20**. The movable bristles are attached to and supported by a movable bristle carrier. Upon activation of a switch or actuator **70** (shown in Fig. **1**) disposed along the handle **80** of the toothbrush **10**, electrical energy such as from one or more batteries in the housing **80**, is directed to a motor **90**. The motor **90** includes a drive shaft **91** to which is affixed a drive gear **92**. The drive gear **92** is engaged with a rotatable drive gear **93**. The drive gear **93** is mounted such that it rotates about an axis **A** preferably extending in a direction perpendicular to the drive shaft **91** of the motor. The drive gear **93** includes a pin or drive member **94** which is disposed on the drive gear **93** radially outward from

the center of rotation, or axis **A**, of the drive gear **93**. Attached to the drive member **94** is a drive ribbon **95**. This arrangement of drive components imparts reciprocating motion to the drive ribbon **95** from a powered rotary drive shaft **91**. As will be appreciated, other gearing arrangements can be provided between the motor **90** and the ribbon **95**. For example, various drive mechanisms described in U.S. Patents 6,178,579; 6,189,693; 6,360,395; and 6,371,294 might be adapted or utilized.

Figs. **6 to 8** illustrate the configuration and engagement of the distal end of the drive ribbon **95** to a movable bristle carrier **52** disposed on or within the head **20**. Specifically, the distal end of the drive ribbon **95** extends through a channel defined within the neck **40** as shown in Figs. **6** and **7**, and is exposed or otherwise accessible in the region of the head **20**. The movable bristle carrier **52** is movably retained along the brush head **20**, such as within a channel or slot defined in one or more faces of the head. As shown in Fig. **8**, the movable bristle carrier **52** is engaged to the distal end of the drive ribbon **95** by a pin **54**. It will be appreciated that other types of engagement may be used between the carrier **52** and the ribbon **95**. Preferably, the pin **54** is positioned through an aperture **55** defined in the movable bristle carrier **52**, and further positioned within an aperture **96** defined in the end of drive ribbon **95**. As will be appreciated, the bristle carrier **52** supports and retains a collection of bristles or bristle tufts within one or more apertures **53**.

Fig. **9** illustrates in greater detail, a preferred configuration for the engagement between the motor **90** and the drive ribbon **95**. Specifically, this configuration imparts a reciprocating motion to the drive ribbon **95** upon actuation of the motor **90**. The drive gear **92** is engaged with the rotatable drive gear **93** such that upon operation of the motor **90**, the drive gear **93** is rotated about axis **A**. As can be seen in Fig. **9**, the drive gear **93** includes a drive member **94** to which is engaged an end of the drive ribbon **95**. The drive member **94** is located off-center, or radially outward, from the axis of rotation **A** of the drive gear **93**. The engagement between the drive member **94** and the drive ribbon **95** enables angular or pivotal movement of drive ribbon **95** at the point of attachment of drive member **94**. Rotation of the drive gear **93** imparts a reciprocating motion to the

drive ribbon **95** as a result of the location of the drive member **94** relative to the axis of rotation **A** of the drive gear **93**. The stroke of the reciprocating movement imparted to the drive member **95** can be increased by locating the drive member **94** radially outward and further away from the axis of rotation **A** of the drive gear **93**. And, the stroke may be decreased by locating the drive member **94** closer to the axis of rotation **A**. The frequency of the reciprocating movement is adjusted by changing the rate of rotation of the drive gear **93**. This may be accomplished by modifying the gearing relationship between gears **92** and **93**, or by providing a different rate of rotation of the motor **90** and drive shaft **91**.

Upon operation of the motor **90**, it will be appreciated that a lateral component of movement will also be imparted to the drive ribbon **95**, in addition to a reciprocating component of movement. These descriptions of motion are with respect to the longitudinal axis of the drive ribbon **95**. This lateral component of movement is not expressed in the corresponding movement of the bristle carrier **52**. Loss of this lateral component of movement is due to the pinned engagement between the distal end of the drive ribbon **95** and the bristle carrier **52** shown in Fig. **8**. Besides this pinned arrangement, and as previously noted, it will be appreciated that other types of attachment may be utilized. For example, it may in certain applications be preferred to employ a "snap-on" connection between the distal end of the drive ribbon **95** and the bristle carrier **52**. This approach is generally preferable over techniques involving separate pins and other fastening components.

Another aspect of the present invention relates to the design of the drive ribbon **95**. The drive ribbon is relatively small in terms of its cross-sectional area. Although the drive ribbon cross-sectional shape may be in a variety of forms including but not limited to round, off-round, triangular, elliptical, square, rectangular, circular, non-circular and oval for instance, the cross-sectional shape is essentially matched to the cross-sectional shape of the channel defined within neck **40**, as shown in Fig. **7**. Thus, if the channel in neck **40** has a rectangular cross-sectional shape, then preferably, so does the cross-section of the drive ribbon **95**. Alternatively, the cross-sectional shape of the channel defined in the neck **40** may be tailored depending upon the cross-sectional shape of the drive

ribbon **95**. Details of preferred cross-sectional configurations for cavities defined in necks of preferred embodiment toothbrushes are described herein.

It is preferred that the cross-sectional shapes of the channel defined in the neck **40** and of the drive ribbon **95** be matched so that the degree of flexure in the drive ribbon **95** upon application of compressive force is minimized. Referring to Figs. **5-9**, it will be appreciated that upon rotation of drive gear **93**, a reciprocating motion will be imparted to the drive ribbon **95**. That motion will include a "push" or compressive stroke in which the drive ribbon **95** is pushed away from the motor **90**, and a "pull" or tensile stroke in which the drive ribbon **95** is pulled toward the motor **90**. The material forming the drive ribbon **95**, described in greater detail herein, has sufficient strength to transfer the tensile force applied to the drive ribbon **95** by the gear **93** and does not significantly flex or undergo dimensional distortion. However, upon application of a compressive force by gear **93**, the relatively small cross-section of the drive ribbon **95** may permit the ribbon to flex or bend relative to the channel of the neck. As will be appreciated, this is undesirable. Furthermore, bending of the ribbon **95** is an indication of inefficient transfer or loss of energy to the movable bristle carrier **52** engaged at the other end of the drive ribbon **95**. Accordingly, it is preferred to appropriately size and configure the interior span or opening of the channel defined within the neck **40** so as to prevent or minimize flexure of the drive ribbon **95** relative to the channel of the neck, although it will be appreciated that the ribbon is still capable of flexing with, versus relative to, the neck during use.

In addition to matching the neck channel configuration to the cross-sectional shape of the drive ribbon **95**, it is also preferred to size the drive ribbon **95** such that its outer surface is in relatively close proximity to the interior wall of the channel defined in neck **40**. Preferably, the average distance between the outer surface of the drive ribbon **95** and the interior wall of the neck channel, is from about 0.1 mm to about 1 mm and more preferably from about 0.3 mm to about 1 mm. The distance between the outer surface of the drive ribbon **95** and the interior wall of the neck channel can be greater if a bushing is provided about the drive ribbon **95**, in which case the average distance can be up to about 10 mm. It will be appreciated that preferably, the drive ribbon **95** has a uniform

cross-section across its length. However, the present invention includes embodiments in which the drive ribbon **95** has a cross-sectional configuration that is non-uniform and varies at different locations along the length of the drive ribbon **95**.

The drive ribbon **95** may be formed from a variety of materials. Preferably, the drive ribbon **95** is formed from a polymeric material that exhibits sufficient strength to transfer power from the motor to one or more movable bristle carriers **52** disposed on the head of the toothbrush **10** and which, when formed into a thin ribbon, can flex with the flexible neck. Examples of preferred polymeric materials include, but are not limited to, self-lubricating materials such as Celcon™ acetal copolymer (polyoxymethylene (POM)) manufactured by Ticona, Inc., polymeric materials such as ABS, nylon, PPE, POM (a polyoxymethylene copolymer), and Delrin™ acetal resins available from DuPont™; and metals such as steel and aluminum. The most preferred material for forming the drive ribbon **95** is Celcon™. It is also contemplated to utilize other materials for forming the drive ribbon **95**. Furthermore, it may be desirable to provide a low friction coating on the exterior surface of the drive ribbon **95** to minimize friction between that component and the interior walls of the channel defined within the neck **40**.

While a reciprocating ribbon **95** has been illustrated herein, it will be appreciated that a flexible shaft that rotates, ocillates, or undergoes an orbital motion could be provided within the flexible neck **40**. For example, a flex shaft, such as that formed by a group of wire strands helically wound about a wire core, can be used in place of the ribbon to transmit motion to the movable bristle carrier **52**. Further while a Figs. **5** to **9** illustrate one drive mechanism for transmitting motion to a movable bristle carrier, a wide array of drive mechanisms, drive motor and gearing configurations may be adapted and suitable for use with the present invention. While the toothbrush **10** has been illustrated with a flexible neck that is formed integrally with the toothbrush handle, it is contemplated that the neck (or head) might be releasably attached to the toothbrush **10**, as is known in the art.

In addition to selecting a certain cross-sectional configuration for a channel defined within a neck, based upon the cross-sectional shape of the drive ribbon or shaft, or vice-versa; the channel cross-section may either depend upon or influence the selection of the cross-section for the neck. For example, by appropriately selecting the cross-sectional shape and dimensions of the neck, the channel configuration, and the orientation of these shapes relative to each other, varying degrees of directional stiffness or flexibility may be imparted to the neck and brush head in combination with the polymer blends disclosed herein or other elastomeric or soft polymers.

Generally, regions of reduced wall thickness are provided along the neck and/or neck region of the toothbrushes. The preferred embodiment toothbrush **10** features a relatively small head **20** and neck **40** relative to the size of its main body or handle **80**. The minimum frontal width of the preferred embodiment toothbrush **10** as measured in the region of the neck **40**, designated as NW_F, ranges from about 5 mm to about 12 mm, and preferably from about 6 mm to about 9 mm. This span or dimension is approximately 15% to about 55%, and preferably from about 18% to about 41%, of the maximum frontal width designated as HW_F of the body or handle **80**. This is illustrated in Fig. **10**. The maximum frontal width of the brush head **20**, designated as BW_F, ranges from about 10 mm to about 16 mm, and preferably from about 7 mm to about 9 mm. This span or dimension is approximately 31% to about 73%, and preferably from about 22% to about 41% of the maximum frontal width HW_F of the handle or body **80**. Similarly, the minimum side width of the neck **40**, designated as NW_S in Fig. **11**, ranges from about 5 mm to about 12 mm, and preferably from about 6 mm to about 9 mm. This side span NW_S, expressed as a proportion of the maximum side width of the handle or body **80**, designated as HW_S, ranges from about 12% to about 40%, and preferably from about 15% to about 30%. The maximum side width of the handle or body **80**, HW_S, is illustrated in Fig. **11**. The maximum side width of the brush head **20**, designated as BW_S, and exclusive of any thickness dimension from one or more bristle carriers, ranges from about 6 mm to about 12 mm, and preferably from about 7 mm to about 9 mm. This span or dimension is approximately 15% to about 40%, and preferably from about 17%

to about 30% of the maximum side width HW_S of the handle or body **80**. It will be understood that the present invention includes embodiments in which the dimensions and proportions of the brush head and neck are greater or lesser than the noted body or handle portions.

Figs. **12-20** are cross-sectional views taken along the neck of various electric toothbrushes in accordance with the present invention. Specifically, each of these cross-sections illustrate various exemplary cross-sectional configurations for the shape of the neck and the interior channel defined within the neck within which the drive ribbon or shaft resides. It will be appreciated that in all of these figures, a drive ribbon or shaft, although not shown, is disposed within the channel defined in the neck.

By way of example, Fig. **12** illustrates a toothbrush **100** comprising a neck **140**, a channel **142** defined therein, and a plurality of bristles **150** on a brush head (not shown). In this embodiment, the channel cross-sectional shape is elliptical or oval and oriented such that the major axis of the channel cross-sectional shape is generally perpendicular to the orientation of the bristles **150**. And, the cross-sectional shape of the neck **140**, i.e. of the outer surface of the neck **140**, is generally round or circular. The primary direction of bending of this shape is illustrated by the double headed arrow. The minimum wall thickness of the neck, which in this case is located at the side surfaces of the neck, is preferably between about 1 mm and about 3 mm, although this value can be varied depending on the polymer or polymer blend used to form the neck. This cross-sectional shape can be used to control the direction of bending of the flexible neck so that it primarily bends in a rearward or forward direction as shown by the arrow. In contrast, Fig. **14** illustrates a flexible neck that primarily bends in lateral or side-to-side direction.

Figs. **13** to **20** illustrate further embodiments of the toothbrush comprising a neck, a channel defined therein, and bristles extending from a brush head (not shown). The cross-sectional shape of the channels (e.g., **242, 342, 442, 542, 642, 742, 842, 942)** vary from circular to elliptical or oval. The major axis of the neck cross-sectional shape may generally be perpendicular to the orientation of the bristles (e.g., Fig. **16**) or generally parallel to the orientation of

the bristles (e.g., Fig. **17**). The major axis of the channel cross-sectional shape may be generally perpendicular to the major axis of the neck cross-sectional shape (e.g., Fig. **16**) or generally parallel to the major axis of the neck cross-sectional shape (e.g., Fig. **15**). The primary direction of bending of each cross-sectional shape is illustrated by a double headed arrow. The minimum wall thickness of the neck is preferably between about 1 mm and about 3 mm, although this value can be varied depending on the polymer used to form the neck and the desired flexibility. It will be understood that the present invention includes neck and channel cross-sectional shapes, combinations of shapes, and orientations in addition to those shown in the referenced figures.

The extent of stiffness, rigidity, or flexibility of the neck may be controlled by appropriate selection of the shape and orientation of the neck and the shape and orientation of the channel defined within the neck in combination with the polymer selection. Neck cross-sections having regions of wall thickness that vary at different locations along the cross-section, will impart stiffness-altering properties to the neck so, for example, a neck might bend with a compound radius of curvature. Thus, wall regions having relatively large thicknesses will be more resistant to bending and flexure at that region, than for instance wall regions having lesser thicknesses or relatively thin walls. Additionally, the stiffness, rigidity, or flexibility may be controlled by appropriate selection of the material(s) used in forming the neck as previously discussed.

Figs. **21** to **23** illustrate partial side views of various toothbrush heads suitable for use with the present invention. Each of these toothbrush heads utilize bristle carriers having certain configurations as described herein that can be used to alter the stiffness of the bristles to change or enhance the effect of the flexible neck. Figs. **21** to **26** illustrate toothbrushes comprising a brush head (e.g., **1420**) and a neck (e.g., **1440**). A movable bristle carrier (e.g., **1452**) is provided on the brush head. A plurality of bristles (e.g., **1450**) are provided on the outer region of the brush head and bristle carrier. The movable bristle carrier can be provided with a convex, concave, irregular, outer surface when viewed from either the side.

Referring to the various bristle carriers illustrated in Figs. **21** to **29**, it can be seen that the profile or configuration of the outwardly facing surface of the carrier, generally referred to herein as a "brush-facing" surface, may be in a variety of forms and shapes. One particularly preferred shape is a concave shape. A concave side configuration such as shown in Fig. **22**, or a concave end configuration such as shown in Fig. **27** may be utilized. Specifically, a concave side configuration refers to a concave shape when viewed in a direction generally perpendicular to a longitudinal axis of the toothbrush. A concave end configuration refers to a concave shape when viewed in a direction generally parallel to and collinear with a longitudinal axis of the toothbrush. The definitions for convex side and convex end shapes are analogous. It is further contemplated to provide a compound concave surface that is concave with respect to both side and end views of the bristle carrier. A concave shape promotes the retention of dentifrice or polishing material that may be used during brushing and can advantageously alter the stiffness of bristles. Likewise, a convex surface such as shown in Figs. **22**, **26**, and **30**, promotes the dissipation of dentifrice in the region of the bristles along the brush head.

The formation of the brush body, i.e., head, neck and handle, as a one-piece mixture of polymer materials according to the present invention provides the advantage of true, multi-directional flexibility. In other words, the head portion of the toothbrush of the present invention can be displaced and oriented in any direction with respect to the handle portion of the brush with ease. This is in contrast to conventional brushes, in which the head has at best only a uni-directional flexing capability with respect to the handle and then only if a force significantly greater than a toothbrushing force is applied. In contrast, the present invention provides a neck that is extremely flexible, in one or more directions, under small forces.

The flexible neck can also act to buffer excessive force on the teeth and gums that may be exerted by a user. As previously noted, application of excessive force during brushing is deleterious to the gums. Accordingly, by appropriate selection of the polymers forming the neck of the preferred

embodiment toothbrush described herein, application of excessive force can be prevented.

The present invention may utilize features, aspects, components, materials, and characteristics from one or more of the following published patent applications or issued patents: WO 01/29128; U.S. Patent 6,000,083; U.S. Des. Patent 432,312; U.S. Des. Patent 433,814; U.S. Patent 6,178,579; U.S. Patent 6,189,693; U.S. Patent 6,311,837; U.S. published patent application 2002/0032941; U.S. Patent 6,360,395; and U.S. Patent 6,371,294; all of which are hereby incorporated by reference.

The foregoing description is, at present, considered to be the preferred embodiments of the present invention. However, it is contemplated that various changes and modifications apparent to those skilled in the art, may be made without departing from the present invention. Therefore, the foregoing description is intended to cover all such changes and modifications encompassed within the spirit and scope of the present invention, including all equivalent aspects.